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DEVICE FOR DETERMINING AT LEAST ONE PARAMETER OF A FLOWING MEDIUM

Background Information

The present invention is based on a device for determining at least one parameter of a medium flowing in a line, having a sensor carrier for accommodating a sensor element, according to the species defined in Claim 1.

The German Patent 44 26 102 C1 and the U.S. Patent 5,693,879 describe a sensor carrier for a sensor element in an air-mass measuring device, the sensor carrier extending with the sensor element into a measuring channel in which a medium is flowing. The sensor element supplies a measuring signal used for calculating the mass of the flowing medium. The sensor carrier has a recess in which the sensor element is flush-mounted and retained by an adhesive layer applied on a bottom surface of the recess. In this case, the sensor carrier is produced in that first of all, an opening which corresponds approximately to the outer shape of the sensor element is made in a metal strip; the metal strip is thereupon bent about a bending axis outside of the recess and then pressed together in such a way that a bent part of the metal strip forms a retaining element, and an unbent part of the metal strip having the opening forms a frame element of the sensor carrier. The retaining element covers the opening of the frame element and, together with the frame element, forms a recess. After that, further deforming of the retaining element produces plateau-like elevations which are used as spacers or bearing surfaces. The sensor element is then glued in place in the recess.

It is extremely important that the sensor element be glued in position in the recess with its top surface as flush as possible with respect to the top surface of the sensor

carrier, since just the smallest displacement, e.g. because of an unevenly applied adhesive layer, results in eddies and flow separation regions which, particularly at the surface of the sensor element, disadvantageously influence the heat dissipation of the measuring resistor and invalidate the measuring result. Therefore, very small mass tolerances must be provided for the recess, and the most extreme care is necessary when gluing the sensor element into the recess of the sensor carrier, so that particularly when the device is mass-produced, a high degree of sophistication is necessary from a standpoint of production engineering, resulting in considerable production costs.

The various work steps for producing the frame and retaining elements are disadvantageous. In addition, the flowing medium can flow through the folding gap between the frame and retaining elements. However, this is not disadvantageous, since this effect can be suppressed by zero-point measuring and calibration; although, during the service life of the sensor element, the measuring result is invalidated if this folding gap is obstructed by dirt and/or liquid particles, and the calibration is no longer correct.

It is disadvantageous that the spacers are first formed by a further shaping process. The tolerance of the depth dimension of the recess is given by the tolerance of the thickness of the metal strip and the tolerance of the folding gap thickness.

It is also disadvantageous that, because of the flowing corrosive medium, a corrosion-protection layer such as NiNiP must be applied on the sensor carrier by an additional costly electroplating process or a coating method which further increases the dimensional tolerances and the production times and costs.

When working with such a self-supporting way of mounting the sensor element, because of tolerances during production, a gap develops between the sensor element and the recess of the sensor carrier. The gap can be so large that in the case of the sensor element, an unwanted flow in the hollow space below its membrane in the recess may come about, which has a disadvantageous effect on the measuring result of the device.

That is why devices are described in the literature with which the disturbing influence of the seepage can be reduced. A diversion of the flow at a specially formed edge of the sensor element, as described in DE 195 24 634 A1 and U.S. 5,723,784, respectively, prevents the medium flowing in via the gap from getting into a hollow space below the membrane of the sensor element. An application of gluing seams, as described in DE 197 43 409 A1, can prevent the penetration of the medium into the gap about the sensor element, in order to avoid unwanted seepage. Disadvantageous in both methods is that only by the special arrangement of gluing seams or by additional measures is the flow diverted around the hollow space in order to compensate for the effects of the manufacturing tolerances.

The German Patent 197 44 997 A1 describes a device which makes it possible to protect the components of an evaluation circuit as well as the connecting lines to the contacting region of the sensor element from moisture using a gel, and soiling of the sensor region, thus, the part of the sensor element where a membrane is located, by the gel is prevented. In that case, expansions of a gap, which runs between the sensor element and the walls of the recess, are provided, in order, with the aid of the expansions, to reliably stop a further flow of a protective layer, applied at least partially on the evaluation circuit, in the gap, so that the flow path of the protective layer always remains clearly defined. In this connection, the disadvantages from the standpoint of production engineering result, that gaps must additionally be created, the flow of

the gel not being stopped, but rather only being diverted in a defined manner.

The German Patent 198 28 629 A1 describes a thermal air-flow sensor in which a carrier housing and a measuring housing are formed separately from one another, and the measuring housing and the carrier housing are cemented on a base plate element.

Summary of the Invention

In contrast, the device of the present invention having the characterizing features of Claim 1 has the advantage that in a simple manner, the measuring result is not impaired even during longer operating time, because the measuring result is not influenced due to a flow under the measuring element by an air stream via an open or clogging folding gap, and according to the invention, the tolerance of the depth dimension of the recess is determined only by the tolerance of the sensor cavity, and no longer additionally by the tolerance of the folding gap.

The measures specified in the dependent claims permit advantageous further developments and improvements of the device indicated in Claim 1.

It is advantageous to secure the sensor carrier in a bypass channel or in a support part, since this simplifies the assembly.

If the sensor carrier is secured to a base member, a sensor element may advantageously be connected to electronic equipment prior to insertion into the device. An aerodynamically formed oncoming-flow edge is advantageous for the oncoming-flow behavior.

For optimized circumflow of the sensor element, it is advantageous if the sensor element is installed flush with

respect to a top surface of the sensor carrier, and/or if a small gap is present between the sensor element and the sensor cavity.

It is particularly advantageous if plastic from the plastics class of liquid crystal polymers, or partial crystalline, aromatic thermoplastic is used.

During assembly, it is advantageous that an adhesive bead, which completely seals the sensor region of the sensor element in the sensor cavity, is placed into the cut-outs in the longitudinal edges of the sensor cavity, transversely over the bottom of the sensor cavity, and that depressions are applied in the edge area of the sensor cavity bottom, so that the sensor element can be mounted more exactly. This adhesive bead prevents soiling of the sensor element by reliably stopping the gel which protects an evaluation circuit from moisture.

It is advantageous to use plastic for the sensor carrier, since forms of a more filigree nature, and aerodynamic requirements such as those of the oncoming-flow edge can be taken into account by the possibilities for shaping the plastic in any way desired.

Moreover, it is advantageous to use plastic or ceramic, since plastic does not corrode so seriously compared to metal, and therefore no further corrosion protection is necessary.

Since it is advantageously possible to place the sensor element very precisely in the sensor cavity due to the narrowing of the tolerances because of the use of plastic, there is no longer any flow below the sensor element.

Brief Description of the Drawing

Several exemplary embodiments of the present invention are shown simplified in the Drawing, and are explained more precisely in the description below.

Figure 1 shows a device for determining one parameter of a medium in the installed state.

Figure 2 shows a sensor carrier, constructed according to the present invention, with installed sensor element.

Figure 3a shows the sensor carrier, constructed according to the present invention, without sensor element.

Figure 3b shows a section along line A-A in Figure 3a.

Figure 4a shows a device having a bypass channel into which the sensor carrier is inserted.

Figure 4b shows a section along line B-B in Figure 4a.

Figure 5 shows a section along line V-V in Figure 3.

Figures 6a and Figure 6b show various arrangements of the sensor carrier and sensor element.

Description of the Exemplary Embodiments

Figure 1 shows schematically how a device 1 is installed in a line 3 in which a medium to be measured is flowing. Device 1 is used for determining at least one parameter of the flowing medium and is made of a measuring housing 6, denoted by a lower rectangle indicated by a dot-dash line, and a support part 7, denoted by an upper rectangle indicated by a dot-dash line, in which, for example, an evaluation electronics 18 is accommodated, for instance, on a base support 26 (Figure 2) in

an electronics space 19. Parameters of a flowing medium are, for example, the volumetric air flow for ascertaining an air mass, a temperature, a pressure, a concentration of a component in the medium or a flow velocity, which are determined by suitable sensors. It is possible to use device 1 for determining further parameters. Parameters may be determined using one or more sensors, one sensor also being able to determine two or more parameters. Measuring housing 6 and support part 7 have a common longitudinal axis 9 which, for example, may also be the center axis. Device 1 is introduced, for example, in a plug-in fashion into a wall 12 of line 3. Wall 12 forms the boundary of a flow cross-section, in whose middle a center axis 14 extends in the direction of the flowing medium, parallel to wall 12. The direction of the flowing medium, in the following known as the main flow direction, is indicated by corresponding arrows 16, and runs there from left to right.

Figure 2 shows a sensor carrier 20 having an incorporated sensor element 33. Sensor element 33 is drawn schematically and partly transparently in Figure 2, and on a surface facing outwardly, has a membrane 35 which forms the sensor region. On the same surface at the other end of sensor element 33 are contacts 38 which produce the electrical connection to electronic evaluation circuit 18. The design of sensor element 33 and the description of the sensor region are explained in greater detail in DE 197 43 409 A1, or in DE 43 38 891 A1 and U.S. 5,452,610, respectively, which are intended to be part of this disclosure. Sensor element 33 is arranged in a sensor cavity 29 in such a way that contacts 38 are closest to base support 26. Here, for example, sensor element 33 is plate-like and is flush with sensor cavity 29. Sensor cavity 29 and sensor element 33 form a gap 44. Here, for example, sensor element 33 and surface 22 of sensor carrier 20 terminate flush.

Figure 3a shows sensor carrier 20 which, for example, is made of plastic. The medium flows past sensor carrier 20 in the direction of arrows 16. In so doing, it strikes on an incoming-flow edge 47 of sensor carrier 20, which, because of the use of plastic, is formed in a particularly filigrain fashion and aerodynamically, e.g., rounded. Sensor cavity 29 having a sensor cavity bottom 30 is situated on surface 22. Sensor cavity bottom 30 forms a retaining element, edges of sensor cavity 29 forming a frame element. Sensor cavity bottom 30 is divided, for example, by an adhesive displacement space 49 into a sensor base area 52 and a bearing surface 54. Sensor base area 52 is furthest from base support 26 and lies below the sensor region of sensor element 33. Bearing surface 54 is closest to base support 26. Here, for example, adhesive displacement space 49 is a channel straight through from one longitudinal edge 57 to opposite longitudinal edge 57' of sensor cavity 29. Longitudinal edges 57, 57' run parallel to longitudinal axis 9. However, it is also possible for adhesive displacement space 49 not to be straight through, i.e. to be shorter. Adhesive displacement space 49 between sensor base area 52 and bearing surface 54 may also, for instance, be formed by at least two depressions in sensor cavity bottom 30. Situated in bearing surface 54 are, for example, four spacers 60 upon which sensor element 33 rests. Spacers 60 are, for instance, plateau-like. One cut-out 63, 63', for example, is formed in each longitudinal edge 57, 57'. For the gluing process, an adhesive bead 65, shown with a dotted line, is applied from cut-out 63 transversely over bearing surface 54 to the other cut-out 63'. After introducing sensor element 33 into sensor cavity 29, sensor base area 52 is completely protected by adhesive bead 65 from a sensor gel which is applied on an electronic evaluation circuit and creeps in an unwanted manner in the direction of membrane 35. After installation, sensor element 33 lies, for example, partly in sensor cavity 29, and rests, for instance, on spacers 60. In this context, sensor element 33 is glued, for instance, to bearing surface 54 by adhesive bead 65 and terminates along

its periphery at the level of surface 22, flush with sensor cavity 29, so that the medium flows scarcely or not at all below sensor element 33 into sensor cavity 29. A gap 44 between sensor element 33 and longitudinal edge 57 of sensor cavity 29 has, for instance, an order of magnitude of a few micrometers. A depth of sensor cavity 29 and the edges of sensor cavity 29 are formed, for example, in such a way that a, for instance, plate-like sensor element 33 may be mounted flush with respect to surface 22. The depth dimensions in the region of bearing surface 54 of sensor element 33, starting from surface 22, are generally toleranced with +/- 10 micrometers. Here, sensor carrier 20 is formed in such a way that surface 22 and the surface opposite it are aligned plane-parallel to one another and in such a way to main flow direction 16 that a vector of main flow direction 16 lies in the plane of the sensor region of sensor element 33. The vector of main flow direction 16 may intersect the plane of the sensor region at a small positive or negative angle. One possibility is to form a cross-section of sensor carrier 20 perpendicular to surface 22 in a wedge-shape, the thinner end of the wedge lying in the region of oncoming-flow edge 47, and the vector of main flow direction 16 not lying in surface 22.

Figure 3b shows a section along line A-A in Figure 3a, sensor carrier 20 in this example having no adhesive displacement space 49 and no spacers 60. A channel end face 67 of sensor carrier 20 joins itself to a wall of a bypass channel 70 (Figure 4), so that no flowing medium gets between channel end face 67 and the wall of bypass channel 70. An adhesive or packing may provide additional sealing along this contact surface. End 68 opposite channel end face 67 has an insert 69 which is inserted into a receptacle 73 (Figure 4b) in the region of electronics space 19 and is connected there by, for example, press-fit or adhesive.

Figure 4a shows measuring housing 6 having bypass channel 70, and support part 7 without a cover closing bypass channel 70.

Bypass channel 70 is formed by a base part 72 and the cover. Main flow direction 16 of the medium is indicated by arrows. Bypass channel 70 is made, for example, of an inlet channel 74 or measuring channel 74, a diverting channel 76, which in turn is divided into a first part 77 and a second part 78, and an outlet channel 80. Flow direction 82, 83 in inlet channel 74 and outlet channel 80 is likewise indicated by arrows. Here, inlet-channel center line 86 is curved, since boundary surfaces 88 of inlet channel 74 are streamlined. Outlet-channel center line 91 here is, for example, a straight line.

In front region 39 of bypass channel 70, in front of an inlet port 97 through which the medium flows in, a flow obstacle 94, for example, is provided which effects a defined flow separation effective for the measuring channel. This is explained in greater detail in DE 44 41 874 A1, and is intended to be part of this disclosure.

A nose 99 of measuring housing 6 is formed, for example, in such a way that solid or liquid particles striking it are reflected away from inlet port 97. To this end, nose 99 is inclined, directed away from support part 7.

A surface 102, drawn in with a dotted line, which runs parallel to main flow direction 16, forms, together with the boundary surface of inlet channel 74 facing support part 7, a screened area into which only a few or no dirt particles or fluids get.

In first part 77 of diverting channel 76, for instance, a boundary surface 104 is inclined by an angle δ contrary to main flow direction 16. Angle δ may lie in a range of approximately 30 to 60 degrees, ideally at about 45 degrees. The influence of this formation is described in greater detail in DE 196 23 334 A1, and is intended to be part of this disclosure. Boundary surface 104 has a depth tr (not shown)

and a width br running perpendicular thereto, which corresponds to at least 2/3 of width b of inlet port 97 of inlet channel 74. Depth tr preferably corresponds approximately to depth t (not shown) of measuring channel 70 perpendicular to its width b at inlet port 97. However, it is also possible to form boundary surface 104 with a depth tr which is somewhat less than depth t of inlet port 97 of inlet channel 74. Contiguous to boundary surface 104, the wall of first section 77 runs approximately in the direction of longitudinal axis 9.

At the end of outlet channel 80 is an outlet port 107 whose surface forms an angle χ with main flow direction 16, and through which the medium leaves the measuring channel again. For example, outlet port 107 has a larger cross-section than outlet channel 80, the pulsation properties thereby being improved. Sensor carrier 20 projects into bypass channel 70, e.g. into inlet channel 74 which forms the measuring channel.

Sensor element 33 is accommodated in sensor carrier 20 and expediently lies in the shaded region of inlet channel 74. The design of such a measuring element 10 is sufficiently known to one skilled in the art from, for example, DE 195 24 634 A1, whose disclosure is intended to be a component of the patent application at issue here.

Electronic equipment 18, which is used for evaluation and control of the sensor element, is disposed in electronics space 19 which is part of support part 7.

Figure 4b shows a section along line B-B of Figure 4a. Sensor carrier 20 is inserted into a receptacle 73 and is secured there by press-fit or adhesive. If adhesive is used, it simultaneously seals a junction region 71 between bypass channel 70 and electronics space 19. Receptacle 73 may be arranged in bypass channel 70, in support part 7 or in between. A side wall 75 of bypass channel 70 is facing away

from support part 7, and longitudinal axis 9 forms an angle of intersection with side wall 75 which is markedly different from zero. Channel end face 67 adapts with form accuracy to side wall 75 of bypass channel 70, so that no seepage occurs there. This may be additionally ensured by applying adhesive or sealing compound there.

Electronic equipment 18 is arranged, for example, on a base support 26 and is coated with a protective gel. Sensor carrier 20 may also be glued to base support 26.

Figure 5 shows a section along line V-V in Figure 3 through sensor carrier 20 with inserted sensor element 33 and adhesive bead 65 (indicated with a dotted line). For example, adhesive bead 65 was placed from cut-out 63 at longitudinal edge 57, across bearing surface 54, to cut-out 63' at longitudinal edge 57'. After the insertion of sensor element 33 into sensor cavity 29, adhesive is pressed, for instance, into adhesive displacement space 49 and through gaps 44, 44' outwardly, and reaches up to surface 22. The adhesive completely closes gap 44 between sensor element 33 and sensor cavity 29 at the one longitudinal edge 57, passing through below sensor element 33 to the other longitudinal edge 57', and gap 44', so that soiling of sensor element 33 with its membrane 35 is prevented by a reliable stop of the creeping protective gel of evaluation circuit 18.

Figure 6 shows various arrangements of sensor carrier 20 and sensor element 33 within measuring housing 6, which is indicated by a dotted line. In Figure 4a, sensor carrier 20 is arranged as follows: A longitudinal axis 9 of sensor carrier 20 is perpendicular to main flow direction 16, and a longitudinal axis of sensor element 33 runs parallel to longitudinal axis 9. In Figure 6a, however, sensor element 33 is arranged in sensor carrier 20 with its longitudinal axis 110 inclined by an angle Φ with respect to longitudinal axis 9. In Figure 6b, a longitudinal axis 112 of sensor carrier 20

is arranged inclined by an angle ϵ with respect to longitudinal axis 9. Longitudinal axis 110 of sensor element 33 runs parallel to longitudinal axis 9. The oncoming-flow and circumflow properties of sensor element 33 and of sensor carrier 20 may be further improved using these arrangements. Furthermore, a preferred orientation of sensor element 33 with respect to main flow direction 16 may thereby be adjusted.